Design of the AAA Power Coupler for the β=0.175 Spoke Resonator

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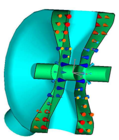
LANL

Workshop on the Advanced Design of Spoke Resonators

Los Alamos, NM, USA

October 7 and 8, 2002

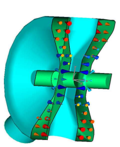


Introduction

- Special considerations for spoke couplers
- Geometry choice
- Multipacting considerations for sizing the coaxial line
- RF parameters for optimized coupler
- Peak fields
- RF losses

Special Considerations for Spoke Couplers

- Small apertures of spoke resonators require coupler attachment to cavity volume
- Magnetic loop vs. coaxial antenna coupling
- Thermal loads of the coupler influence cavity
- Thermal radiation from coupler into cavity needs consideration
- Cavity-Coupler interface might influence frequency



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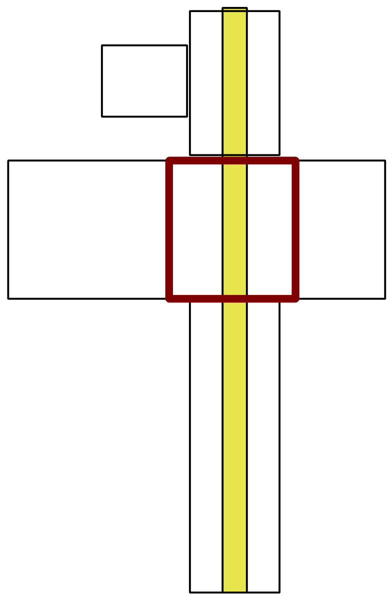
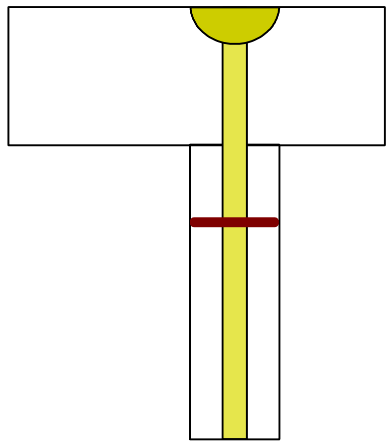
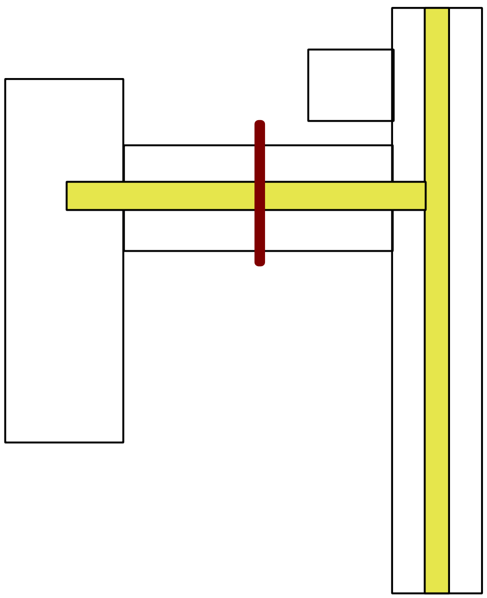
Geometry Choice







Tristan-type
- Free orientation
- Proven w/ beam at 225 kW
- Good vacuum@ window
- Small footprint
- Low cost

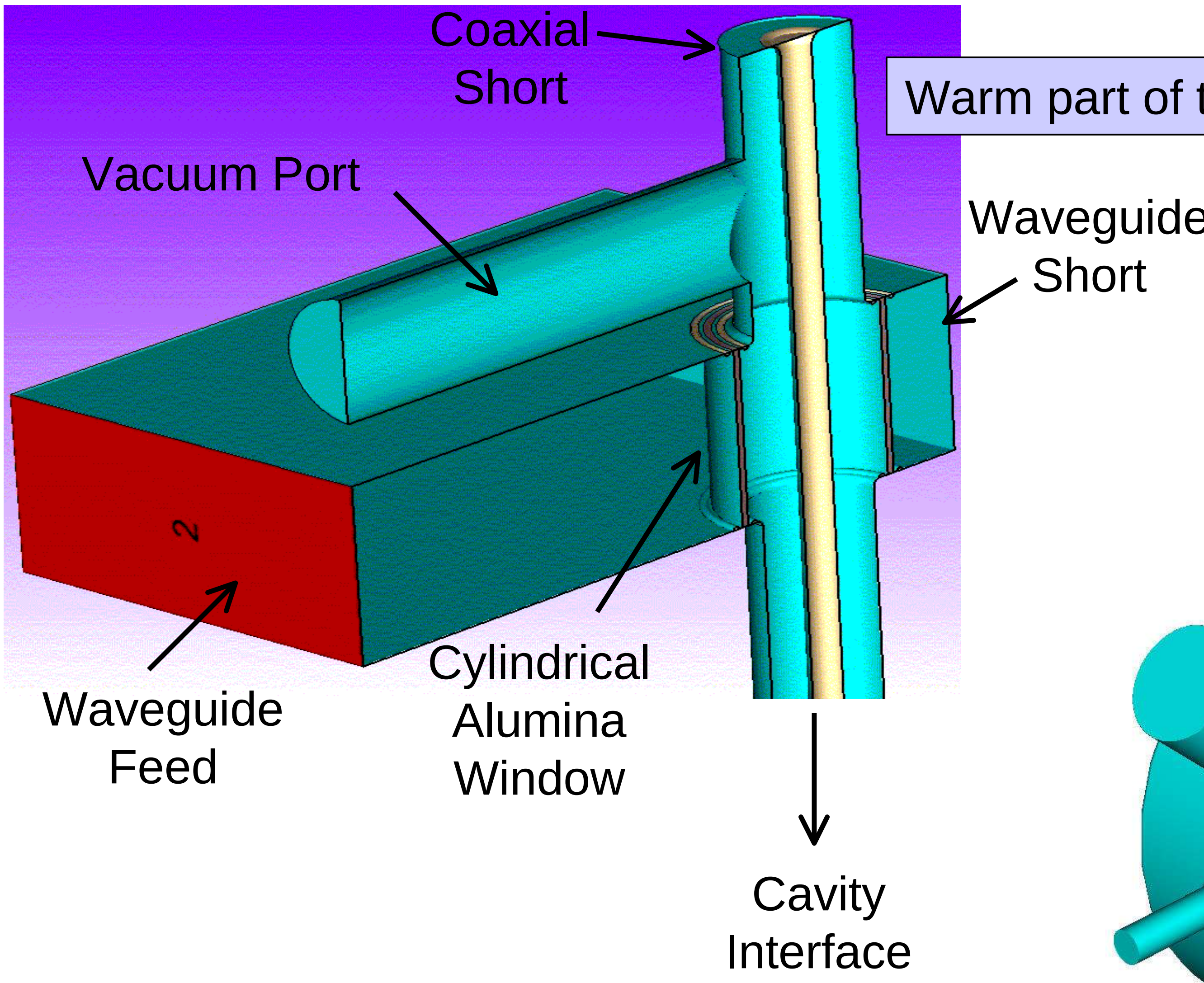
KEK-type
- Proven w/ beam at 380 kW
- Small footprint

- Up or down orientation only
- No straight forward addition of additional pump port

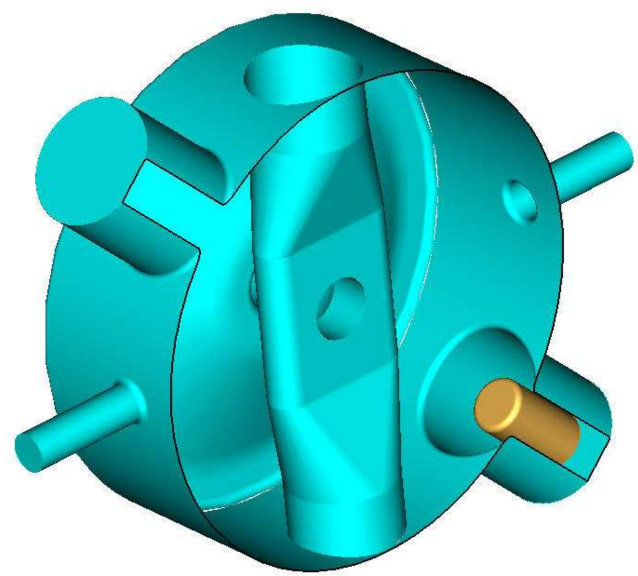
APT-type
- Free orientation
- Proven w/o beam at 1 MW
- Good vacuum @ window
- Local experience

- Big footprint
- High cost

Geometry Features



Warm part of the coupler



Multipacting Consideration for Coaxial Line Size

1. Criterium: Multipacting vs. Beam Power:

Single Point MP levels compared between CERN and derived ADTF scenarios

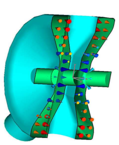
Order	CERN	ED&D-103	ED&D-100	APT-Geo
	352 MHz 75 Ω	350 MHz 75 Ω	350 MHz 75 Ω	350 MHz 50 Ω
7	48 kW	47 kW	42 kW	28 kW
6	52 kW	51 kW	45 kW	30 kW
5	88 kW	86 kW	76 kW	51 kW
4	176 kW	172 kW	153 kW	102 kW
3	234 kW	229 kW	204 kW	136 kW
2	448 kW	438 kW	389 kW	259 kW
1	640 kW	626 kW	556 kW	371 kW

Average Input Power Levels for the Spoke Resonators ($\phi=-30^o$)

	13.3 mA	100 mA
$\beta=0.175$	6 kW	43 kW
$\beta=0.34$	19.5 kW	144 kW
for E_0T = 5 MV/m		

	13.3 mA	100 mA
$\beta=0.175$	8.5 kW	63.6 kW
$\beta=0.34$	28.2 kW	211.8 kW
for E_0T = 7.5 MV/m		

2. Cavity Size: The β=0.175 cavity is limited to coax sizes around approximately 100 mm

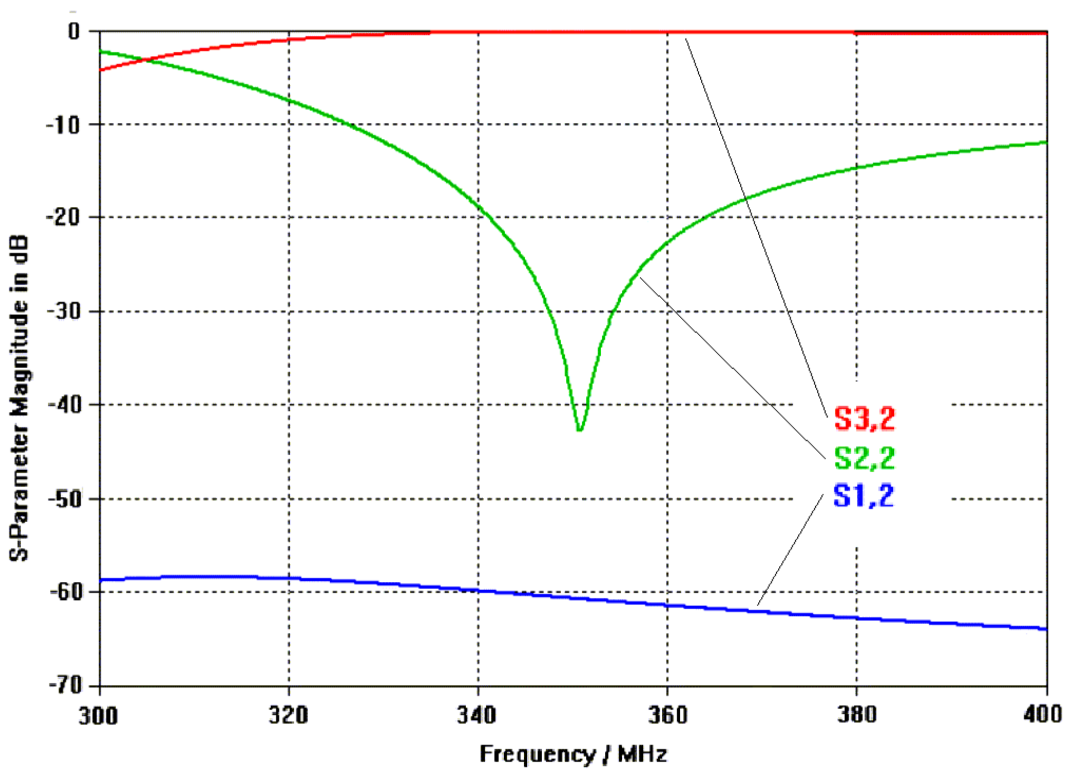


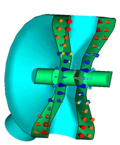
Geometry Parameters and RF Performance

Coax diameter	103 mm
Coax impedance	75 Ω
Waveguide	WR3200
Window-type	cylindrical
Window-material	95% pure (ε = 9.1, tan δ = 0.0027)
Window OD	139.7 mm
Thickness	4.8 mm
Transition	½-height waveguide to λ/4 stub

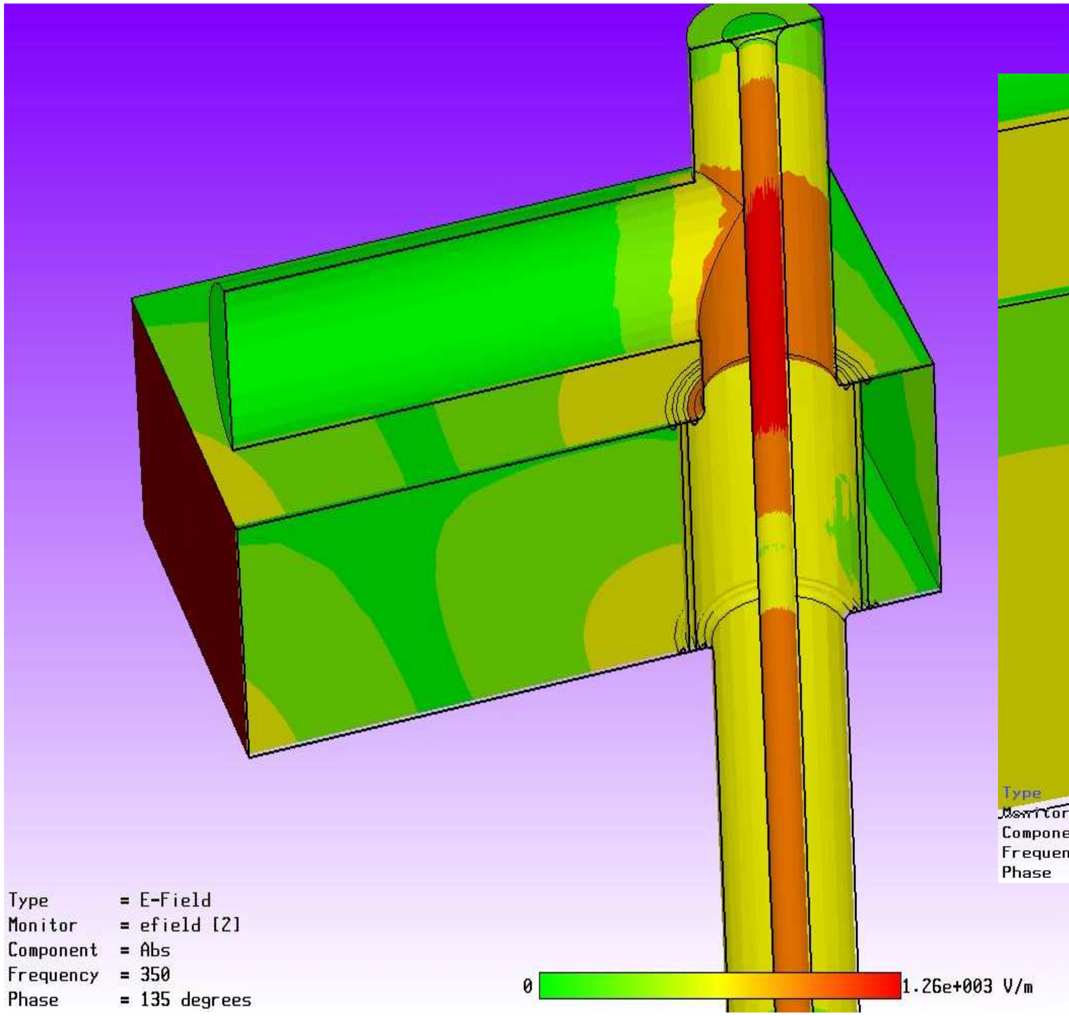
Coax short	305.5 mm to window center
Waveguide short	130 mm to window center
Vacuum port	140 mm to waveguide top
Coax-length	1196.7 mm from short to tip
Pump flange	450 mm to coax center
Orientation	45 degrees from spoke
F_{match}	350.1 MHz
S11	-45 dB
bandwidth	± 11 (3) MHz at -20 (30) dB

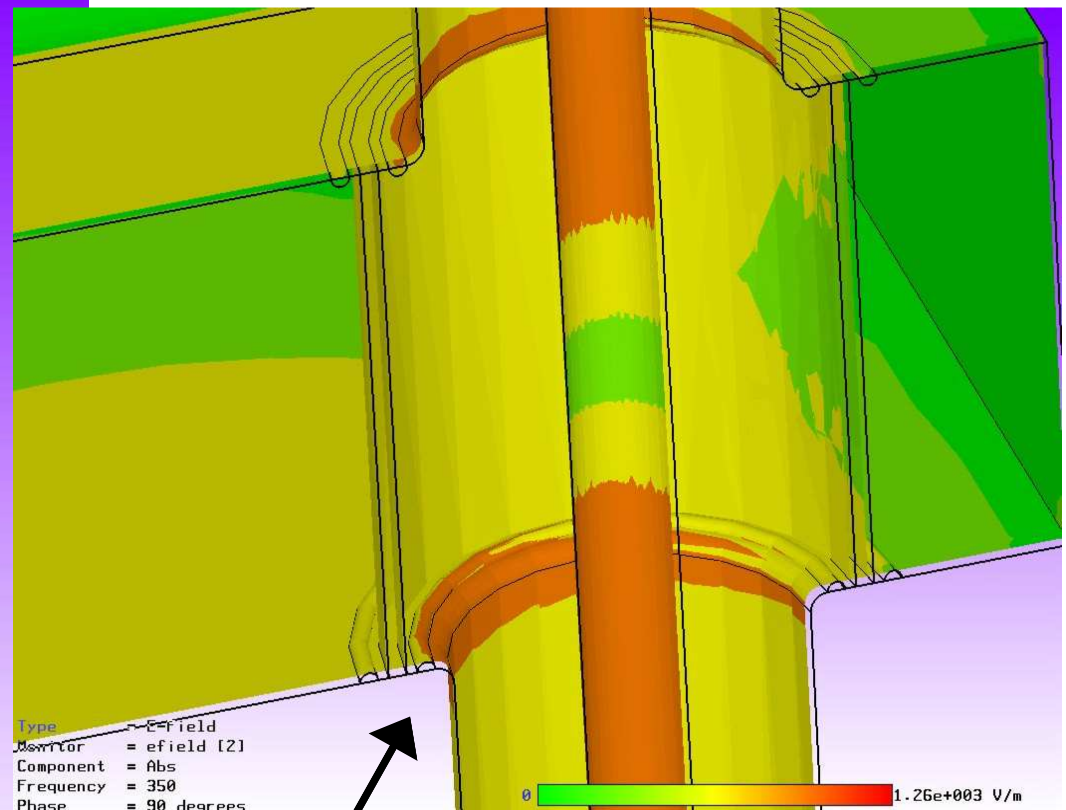
S-parameters





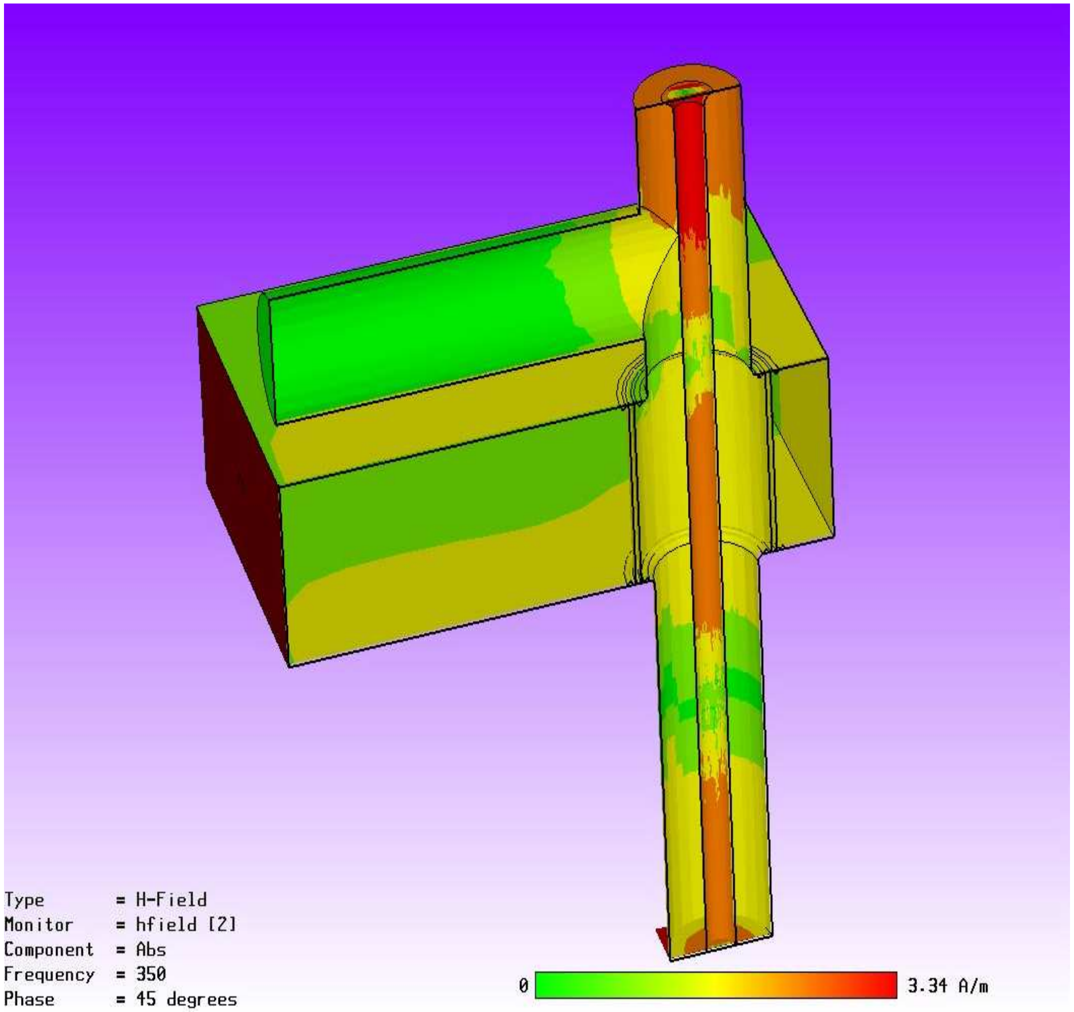
Electric Field

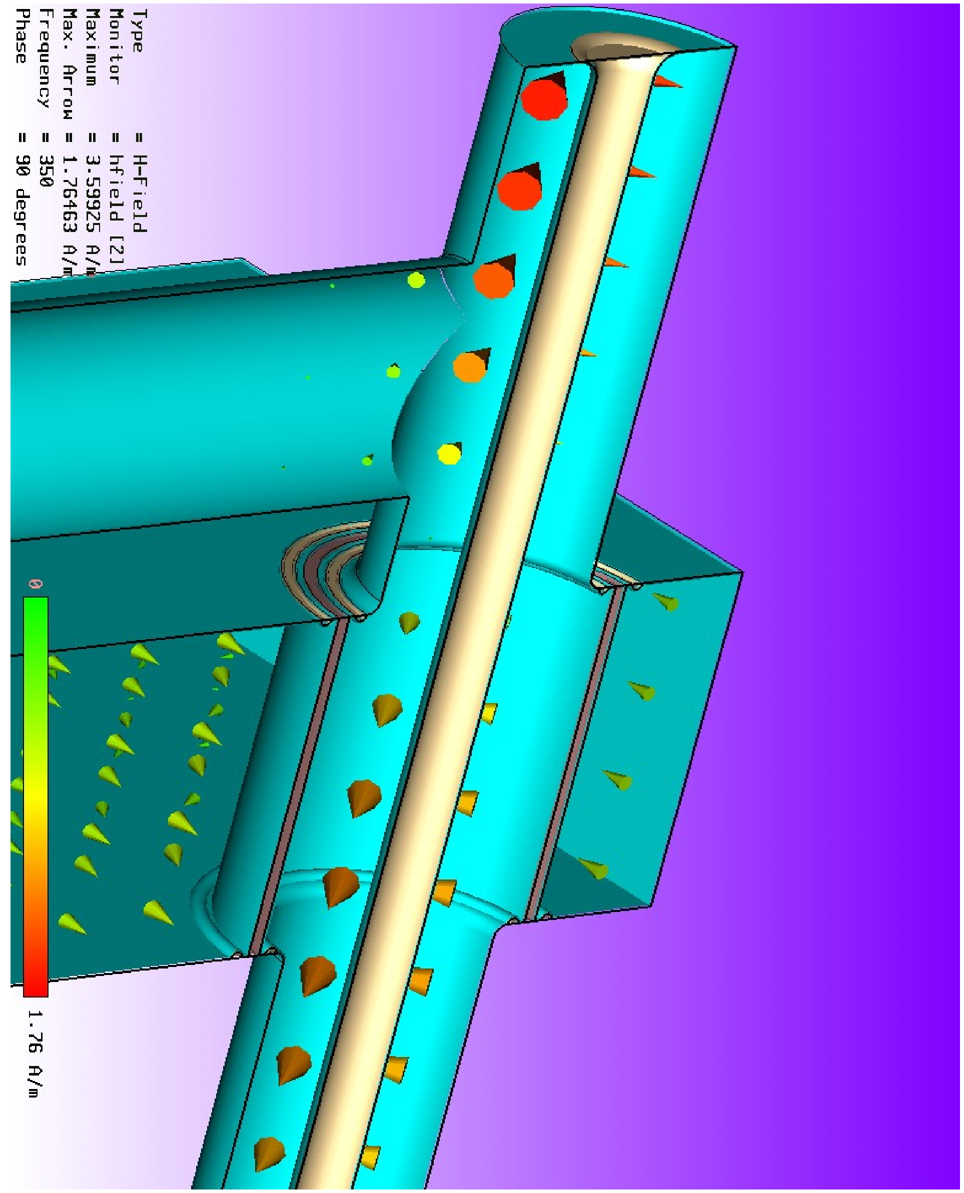




Braze Protection

Magnetic Field



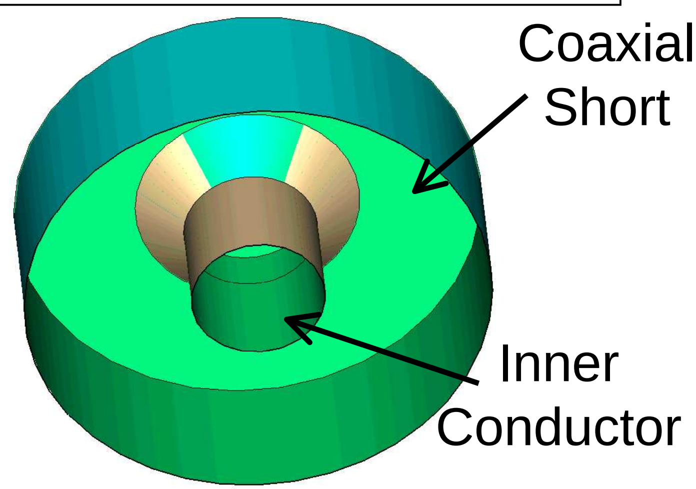


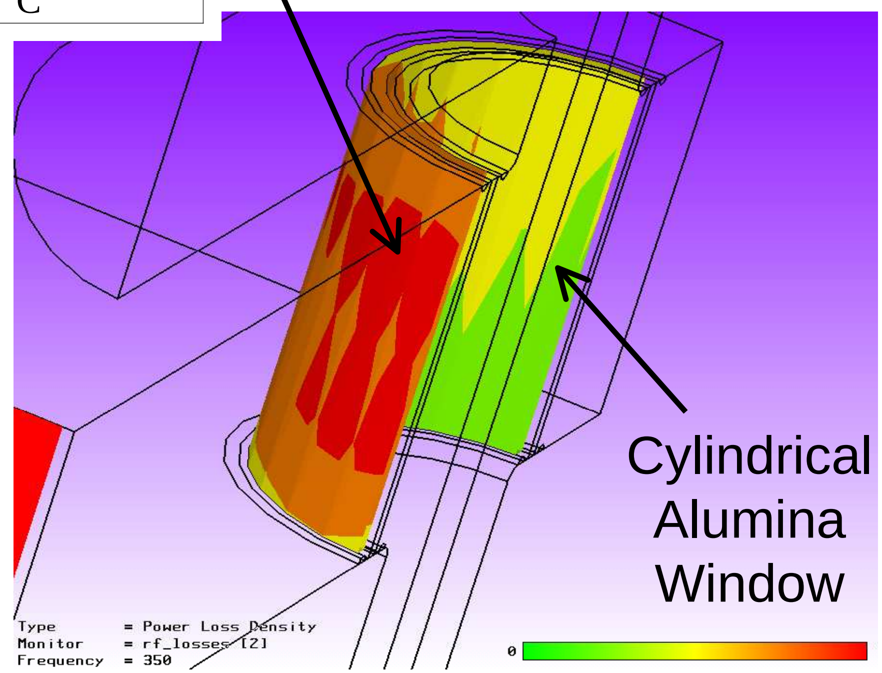
Power Coupler: Thermal/Structural Evaluation

Beam Current Transmitted Power	13.3 mA 8.5 kW	20 mA 12.8 kW	100 mA 63.6 kW
Coax-center, Straight Coax	3.6 W	5.135 W	26.90 W
Coax-center, Actual Coupler	3.94 W	5.93 W	29.48 W
Coax Short	113 mW	170 mW	843 mW
Waveguide Short	116 mW	174 mW	865 mW
Window Ceramic	6.6 W	9.9 W	49.4 W
Peak Loss in Window [W/cm^3]	0.04	0.06	0.27
Peak Temperature on Window	< 47° C		
dT_{max} across Window	2° - 22° C		

Goals:
1. Input for thermal
2. Critical spots
3. Cooling needs

Inner conductor cooling: GHe
Window cooling: dry air





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Summary

- The basic properties of a high power coupler have been selected:
  - coaxial coupler with a $\lambda/4$ wg to coax transition.
  - electric coupling directly to cavity body.
  - coupling scheme has been verified in the lab.
  - coaxial dimensions selected to avoid mulitpacting at operation power level.
- Based on this a RF design has been done with established 3D simulation codes.
- The basic foot print of the coupler has been established.
- Some sensitivites for fabrication are being established.
- The cavity coupler interaction has been studied.
- The basic RF losses have been determined as input for a thermal and stress analysis.
- Further optimization will not change the essence of the results obtained to date.